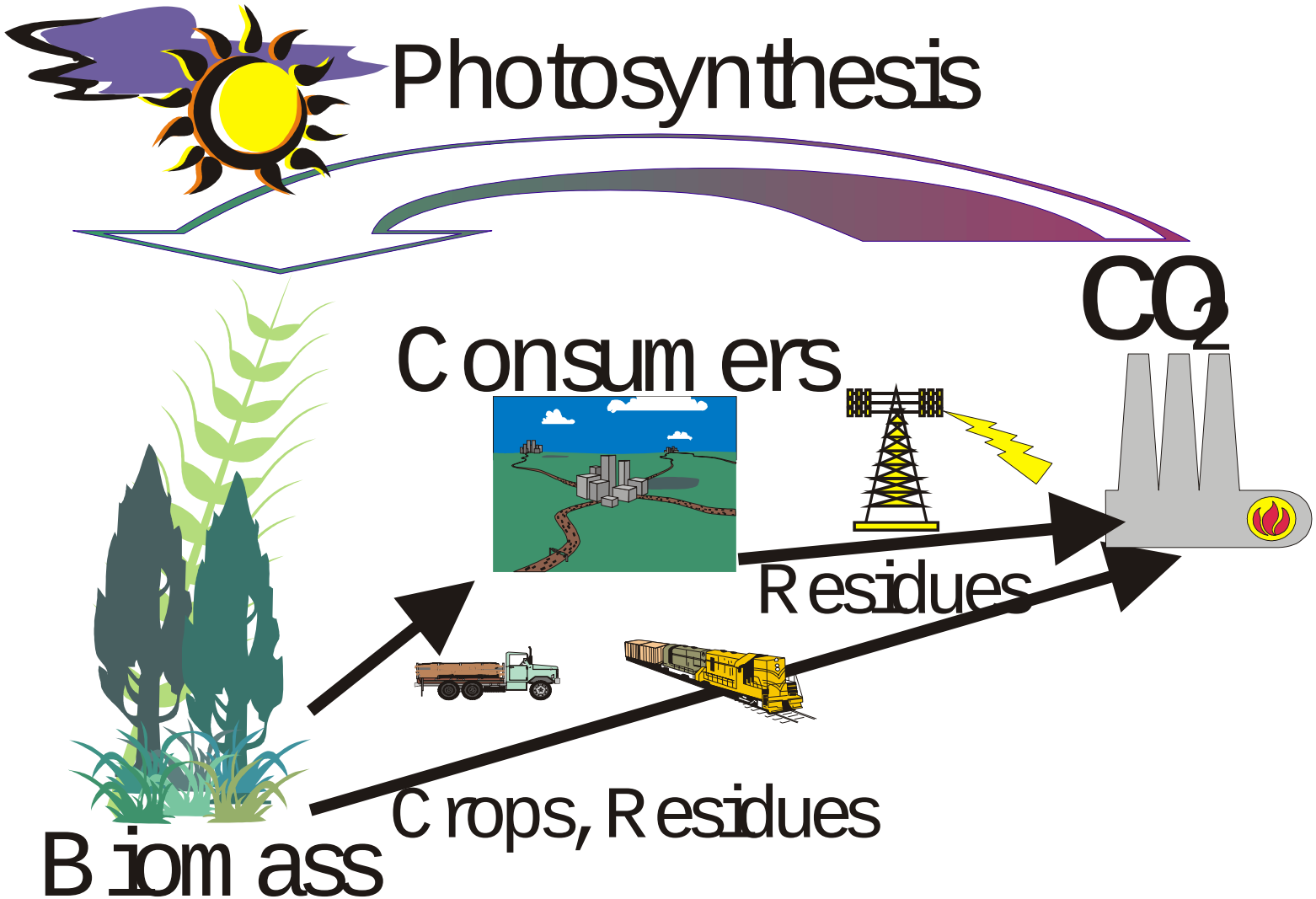
U.S. DOE Natural Gas/Renewable Energy Hybrids Workshop

National Energy Technology Laboratory
Morgantown, WV
August 7-8, 2001

Fuel Crops and Crop Residues

Breakout Session


Photosynthesis
CO2
Consumers
Residues
Crops, Residues
Biomass

The Domain of “Fuel Crops and Crop Residues”

- **All crops, except wood**
- **For purposes of this breakout session, little distinction between fuel crops and crop residues**
- **Consider the whole value chain, “ from farm, to farm gate, to hybrid facility gate, into hybrid facility”**

Fuel Crops and Crop Residues Matrix

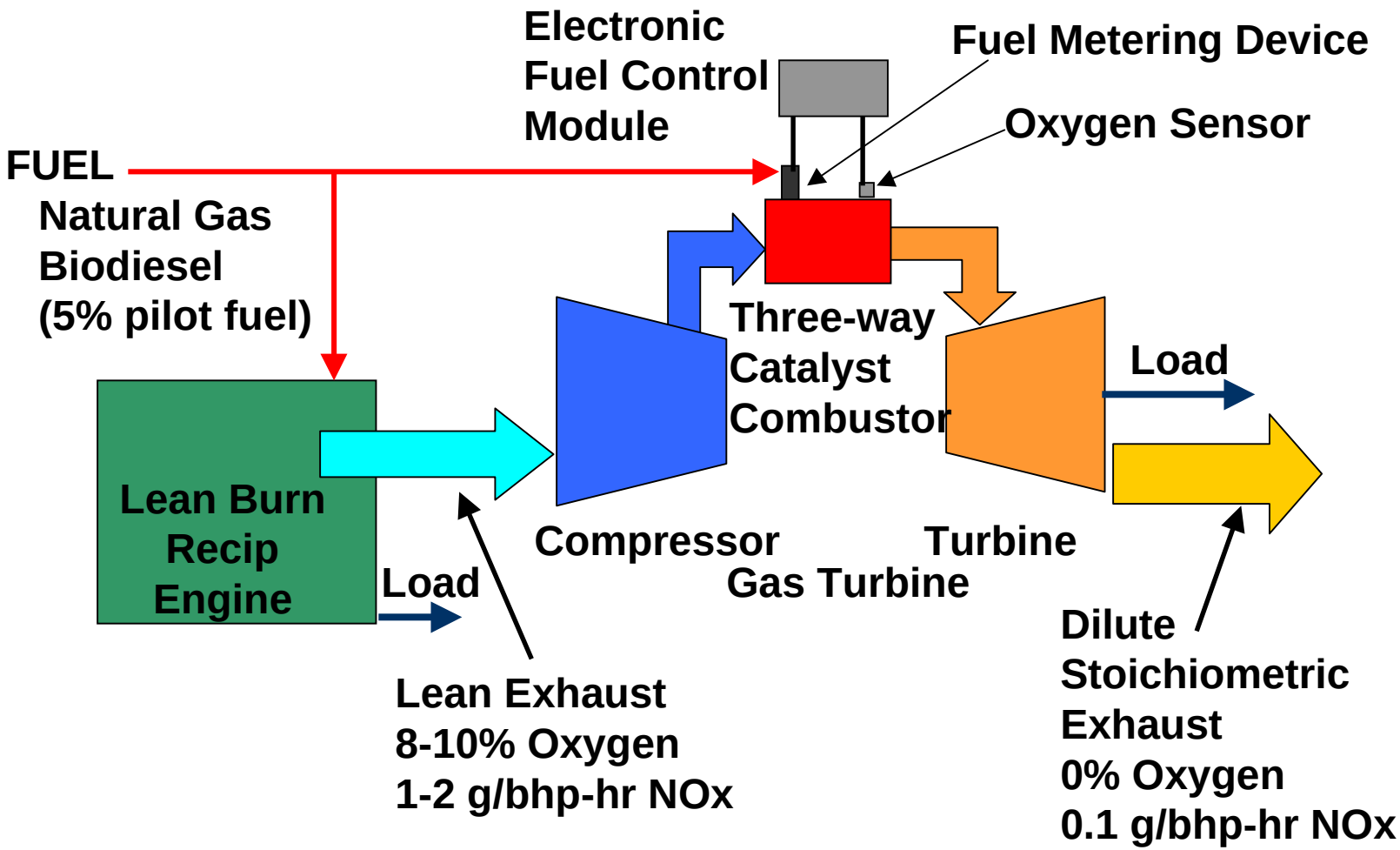
Raw Material	Fuel Type	Prime Mover
Natural Gas	Gas	Reciprocating Internal Combustion
Starch		GT
Cellulose	Liquid	Microturbine
Lignin		Rankine
Oils	Solid	Stirling
Algae (H_2)		Fuel Cells
Bacteria (H_2)	Chemicals	• PEM • Phosphoric Acid • Molten Carbonate • Solid Oxide • Regenerative

Fuel Crops and Crop Residues Hybrids

- **Biogas helps natural gas**
- **Natural gas helps biogas**
- **Natural gas provide infrastructure for biomass**

Hybrid Recip + Gas Turbine

Biofuel Helps Natural Gas



Hybrid Recip + Gas Turbine

Biofuel Helps Natural Gas

Advantages	Disadvantages	Barriers
Low Emissions Improved Efficiency Slight Sustainability Slight reduction in oil import dependence	Complexity	Cost ? Optimum fuel mix? Chemical composition of biodiesel? Compression stage gas turbine technology? Part load vs efficiency schemes? System optimization?

Natural Gas Backs-up Biofuel

- **Natural gas used to compensate for some shortcomings of biogas used in electric generator.**
  - **Combined Cycle Gas Turbine**
  - **Multiple Distributed Recips**
  - **Wind/Recip/Turbine Hybrid**

Natural Gas Backs-up Biofuel

Advantages	Disadvantages	Barriers
Compensate for seasonal and natural disaster variables of biomass Optimize power plant size vs biomass transport Fuel BTU stabilization Fuel price stabilization	Added cost of natural gas infrastructure	Cost ? Distributed or central? –Transmission? –Local load? Economic balancing of two fuels mix? Variable BTU value of biogas? Biomass fuel flexibility?

Natural Gas Replaces Petroleum

- **Natural gas used to power farming and delivery equipment**
  - **Trucks**
  - **Tractors**
  - **Harvestors**
  - **Etc.**

Natural Gas Replaces Petroleum

Advantages	Disadvantages	Barriers
Environmental National fuel security	Added cost of natural gas infrastructure	Cost ? Natural gas fired mobile engines? Rapid refueling?

Crosscutting R&D for "Fuel Crops and Crop Residues"

- Economical analyses & modeling
- Biofuel handling, feeding, etc.
- Gasification technology
- Lifecycle analyses
- Global systems analyses
- Market analyses (niche market value propositions)
- Hardware systems integration analyes